

THE APPROACHING TOTAL ECLIPSE OF THE SUN.¹

V.

The Spectrum of the Corona.

I HAVE already stated that one great advantage possessed by the prismatic camera is that it has enabled us to distinctly separate the spectrum of the corona from that of the chromosphere. It has done this because the coronal radiations are *not* most intense near the prominences.

The following reproduction (Fig. 19) of a photograph, recently published by the Royal Society, will show how clean cut the distinction is. A nearly complete ring is shown in 1474 light, while the H and K light only provides us with dots showing the positions of the brightest prominences.

It is seen at a glance that while the greatest intensities of the H and K light occupy similar positions, the *loci* of greatest intensity in the case of the 1474 light are widely different in position; that is, they do not occupy the same positions as the rings assumed perfect. Careful study shows that the 1474 ring marks out the brightest parts of the corona, and neglects the chromosphere and prominences altogether.

Except in the case of the ring in the green at 1474 of Kirchhoff's scale the coronal rings are very feeble, and

hydrogen, have not previously been recorded by the prismatic camera, though some of the lines corresponding to them appear to have been photographed with slit spectroscopes. The rings photographed in 1893 are compared in the following table with the results obtained by the slit spectroscopes in the years 1882, 1883, 1886,¹ and 1893,² those lines only which are possibly common being included.

Prismatic camera, 1893. λ R.	Slit spectroscopes, 1893 λ A°.	Slit spectroscopes, 1886. λ A°.	Slit spectroscopes, 1883. λ A°.	Slit spectroscopes, 1882. λ A°.
3987	3986·4	3985·0 (1) ³	3986 ?	
4086	...	4084·2 (4)	} 4085	4085
4217	...	4089·3 (4)		
4231	...	4216·5 (3)		
4240	...	4232·8 (5)		
4280	4279·7	4241 (4)	...	4241
4486	...	4280·6 (4)	4279	
		4485·6 (3)		

We see then that all the coronal radiations above referred to probably correspond with lines photographed by Dr. Schuster in 1886. The intensities, however, are not the same.

The number of coronal rings recorded with the pris-

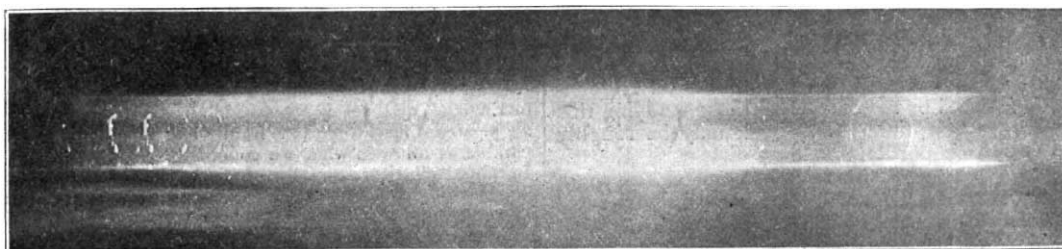


FIG. 19.—The 1474 light ring compared with the prominences as depicted in H and K light during the eclipse of 1896.

their wave-lengths can, perhaps, not be depended upon to within one-tenth metre. They were read off from the African negatives by direct comparison with the spectrum of Arcturus. Possibly, owing to the great intensity of the continuous spectrum, the Brazilian negatives show only the green ring.

The wave-lengths of the coronal radiations are as under, the numbers following them indicating the number of African photographs in which they have been detected.

Wave-length, Rowland.	
3987	(6)
4086	(4)
4217	(2)
4231	(5)
4240	(1)
4280	(2)
4486	(3)
5316·9	(5)
1474 K	

It is almost impossible to form any trustworthy estimate of the relative intensities of the rings, but it may be noted that the one at wave-length 3987 comes next to 1474 K in order of brightness. There are indications of other extremely faint rings, the positions of which cannot be determined with the necessary degree of accuracy to enable a useful statement to be made touching their wave-lengths.

Coronal rings, other than those due to 1474 K, or

¹ Continued from page 368.

NO. 1452, VOL. 56]

matic camera is very much smaller than the number of lines attributed to the corona photographed with the slit spectroscopes in this and previous eclipses. This is, no doubt, partly due to the rings being submerged in continuous spectrum, which is relatively more intense in the case of the prismatic camera. Further, as already pointed out, it is not yet established that many of the lines recorded as being due to the corona by the slit spectroscopes are not due to glare.

By a comparison of the results obtained with slit spectroscopes and prismatic cameras, it would seem to be possible to determine which of the lines recorded by the former instruments really belong to the coronal spectrum. The most intense light will give the strongest glare, and therefore the brightest lines of the chromosphere and prominences will become superposed on those due to the corona. As the results obtained with the prismatic cameras are so very definite with regard to the spectrum of the prominences, it seems only necessary to subtract the common lines of the spectra recorded by the two instruments from the total number recorded by the slit spectroscopes in order to determine those which certainly belong to the corona.

An attempt has been made to investigate the coronal spectrum in this way by reference to the slit spectra of 1886 and 1893, but no satisfactory results can be obtained in this way until slit spectra taken with greater dispersion become available.

¹ *Phil. Trans.*, 1889, A, p. 335. ² *Roy. Soc. Proc.*, vol. 56, p. 20.

³ Intensity on a scale where 6 = brightest line.

In the case of the rings photographed in 1893, the evidence that they truly belong to the corona is absolutely conclusive. In the absence of more exact knowledge of the wave-lengths of the radiations producing the rings, it is not yet possible to determine if they are represented by dark lines in the Fraunhofer spectrum, but it can already be stated that, if present at all, they are among the feeble lines.

A point of some importance is the apparent absence of the 1474 K ring from the spectra of the chromosphere and prominences. Its absence from the prominence spectrum was noted by Respighi in the eclipse of 1871. I am not aware of any observation in which the *form* of a prominence has been observed in 1474 light. All these facts seem to indicate that when the 1474 line is observed at the sun's limb without an eclipse, the spectrum of the corona itself is under examination, under the same conditions as those recorded in the eclipse photographs.

Of the other coronal rings photographed in 1893, those at wave-lengths 4217 and 4280 are approximately coincident with feeble prominence radiations, but since the other coronal rings are not represented in the prominences, the coincidences may be regarded as accidental.

been photographed as rings in the spectrum of the *corona* with the prismatic cameras. They have, however, been occasionally recorded as corona lines with slit

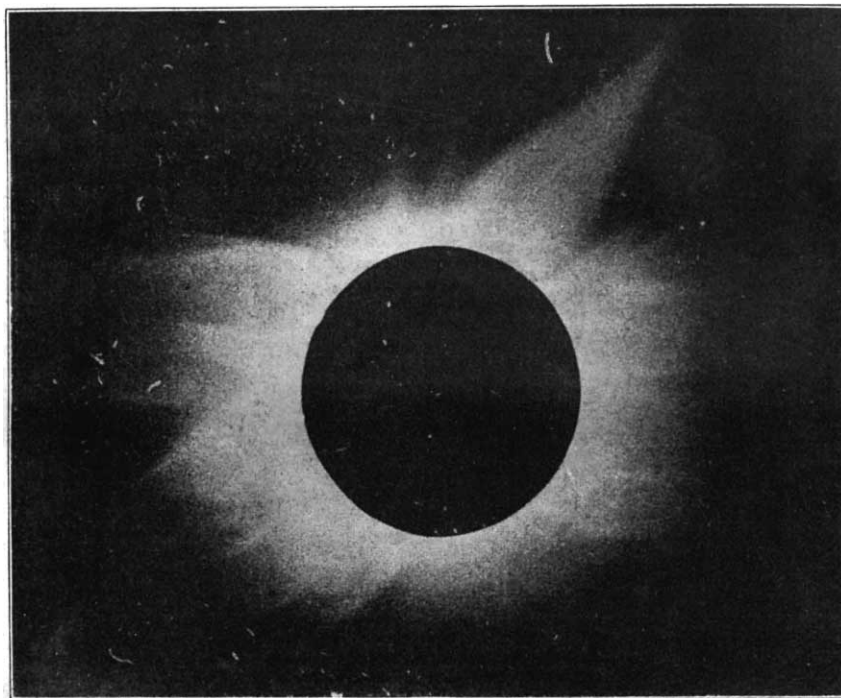


FIG. 20.—The Corona of 1896, Kostinsky.

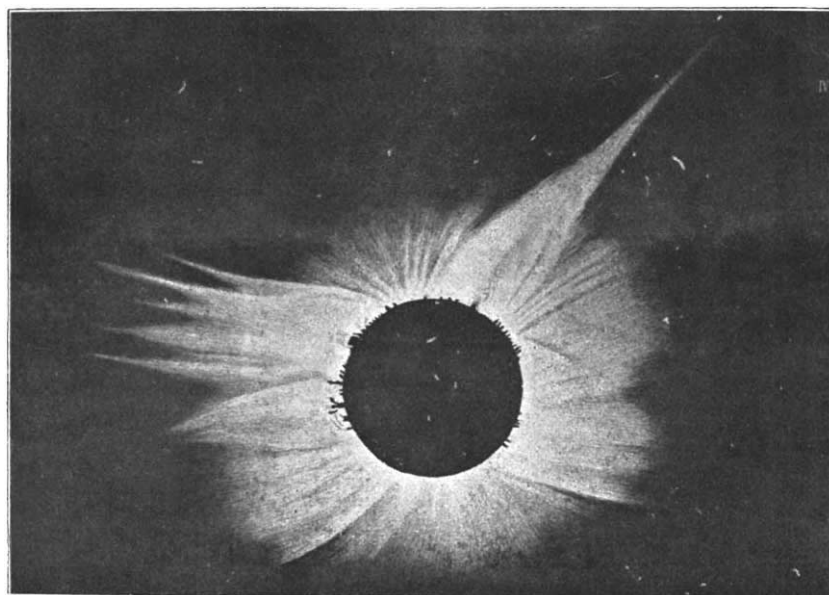


FIG. 21.—Drawing bringing together all the details shown on Kostinsky's and Hansky's photographs. (Prominences shown in black.)

Although H and K are by far the most intense of the radiations of the prominences, on no occasion have they

most cases they were produced by prominence light scattered by our atmosphere, as before explained—light of which the prismatic camera takes no account.

Perhaps the most decided evidence in favour of the existence of H and K in the corona spectrum is that depending upon the photographs taken with slit spectroscopes in 1886; Dr. Schuster states that "the lines end sharply with the corona, and we must conclude, therefore, that in spite of the unfavourable atmospheric conditions, there was but little light scattered by our own atmosphere in the neighbourhood of the sun." But in spite of this observation, Dr. Schuster has concluded that H and K "do not form part of the normal spectrum of the corona";¹ and I may add that the prismatic camera strengthens this conclusion.

The photographs taken with the prismatic cameras in 1893 show a pretty strong "continuous" spectrum, but it has already been explained that

this appearance may have been produced by a very

¹ *Phil. Trans.*, vol. 180, A p. 341.

complicated spectrum, such as that which I observed in the corona in 1882. Concerning my observations, I wrote:—¹

"Instead of the gradual smooth toning seen, say, in

observations were made, we have no evidence as to the visibility of the 1474 ring in those years.

Although there can be no doubt as to a more or less regular change of intensity in the case of 1474 K, the evidence with regard to other radiations is less conclusive.

The Form of the Corona in 1896.

For our knowledge of the Corona as photographed in 1896, we are so far dependent upon the communication made to NATURE by Baron Kaulbars, touching the results obtained in Finland (NATURE, vol. lv. p. 298), and the important collection of memoirs communicated to the Imperial Academy of Sciences of St. Petersburg, brought together in a volume of 144 pages recently published, giving an account of the work in Novaya Zemlya and on the Amur. The volume contains some admirable reproductions of the photographs taken by MM. Kostinsky and Hanksy at Malya Karmakouly in Novaya Zemlya. A copy of M. Kostinsky's second photograph exposed during ten seconds is given here (Fig. 20).

In a drawing MM. Kostinsky and Hanksy have brought together all the details they have been able to trace on their negatives, as well as the positions of all the prominences observed (these are shown in black for greater clearness) (Fig. 21).

It is certainly very fortunate that these photographs of the corona, together with the still unpublished one obtained by Sir George Baden Powell, were secured, since

the spectrum of the limelight, there were maxima and minima, producing an appearance of ribbed structure, the lines of hydrogen and 1474 being, of course, over all. This observation, however, requires confirmation, for the look I had at the corona spectrum was instantaneous only."

A change in the spectrum of the corona was placed beyond all doubt in my own mind by my observations in 1871 and 1878. With reference to this I wrote as follows in 1878 (NATURE, vol. xviii. p. 460):—

"The utter disappearance of the large bright red corona of former years in favour of a smaller and white one in this year of minimum struck everybody. Indeed, it is remarkable that, after all our past study of eclipses, this last one should have exhibited phenomena the least anticipated. It isolates the matter that gives us the continuous spectrum from the other known constituents. The present eclipse has accomplished, if nothing else, the excellent result of intensifying our knowledge concerning the running down of the solar energy. On the former occasion, in 1871, the 1474 ring was very bright, but in 1878 I did not see it at all."

As the sunspot period is one of about eleven years, it was to be expected that the conditions of 1871 would be repeated in 1882 and 1893, and during both these eclipses the 1474 ring was photographed with the prismatic cameras. The photographic plates employed in 1875 and 1886 were not sensitive to the green, and, since no eye

¹ Roy. Soc. Proc., vol. 34, p. 299.

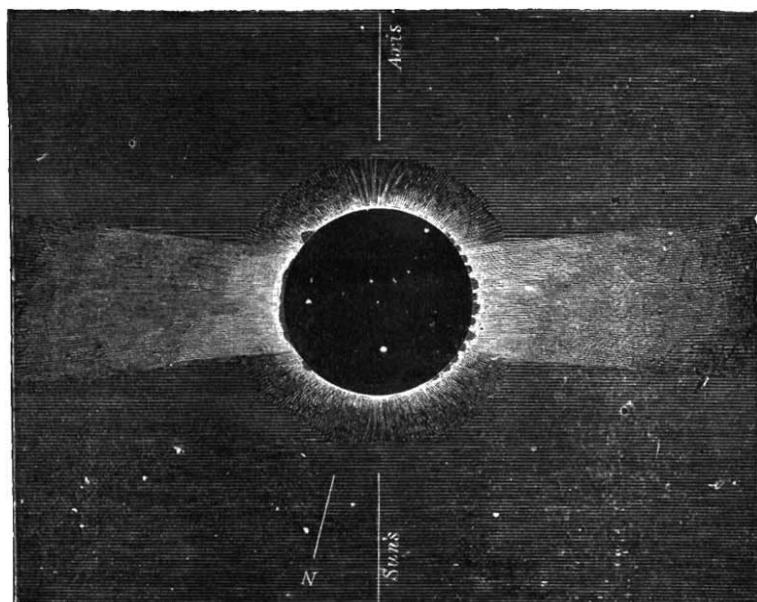


FIG. 22.—The Corona of 1867.

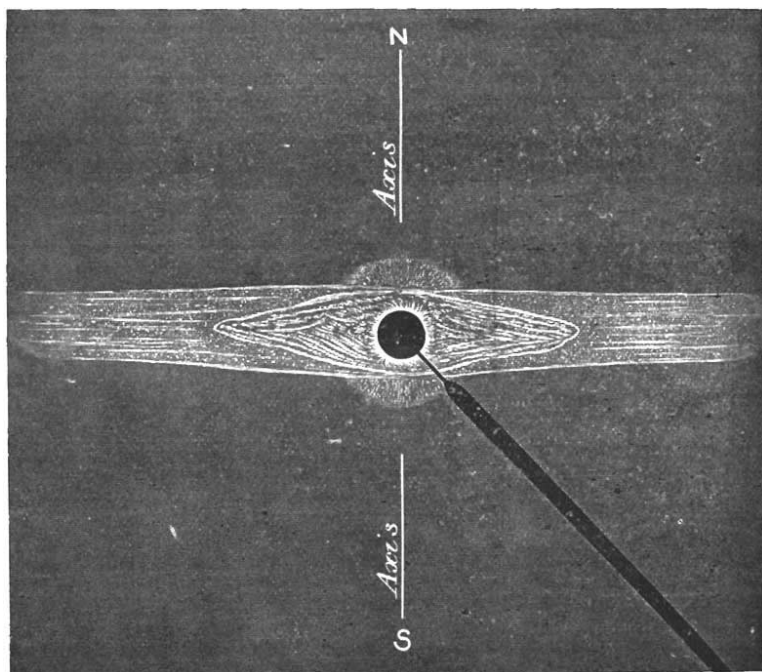


FIG. 23.—The Corona of 1878, as observed by Newcomb by means of a disc.

they support statements made now many years ago touching the change of form of the corona, as well as its spectrum, in relation to the sunspot period (see my "Chemistry of the Sun" (1887), pp. 438 *et seq.*).

If we take the simplest case first, that of minimum sunspots depending upon minimum solar activity, we then get chiefly a well-developed equatorial elongation with a marked absence of irregular streamers in mid-latitudes. In support of this, I append two drawings (Figs. 22, 23) made at the eclipses which took place in the years 1867 and 1879, years of sunspot minimum. In the second drawing, made by Prof. Newcomb, the disc is shown by which he eclipsed the brighter lower reaches of the corona, so as to give his eye the best chance of seeing feeble extensions. The pole supporting the disc was vertical, but it is shown slantwise in the illustration because it is most important to show the sun's axis upright.

At the minimum period not only are these extensions best seen, but the exquisite structure near the sun's poles is very strikingly revealed.

At and near the maximum all this is changed, and we get streamers and their separating rifts very irregularly distributed. In 1896 these irregular streamers form striking objects, and we know from the sunspot observations that the atmosphere was more than usually disturbed—more than might have been anticipated, seeing that the maximum was due to occur in 1892.

I am glad to find in the valuable collection of Russian memoirs to which I have referred an important paper by M. Hansky, calling attention to the way in which the form of the corona varies with the sunspot period. His studies entirely confirm all I have written on this subject.

NORMAN LOCKYER.

THE INTERNATIONAL CONGRESS OF MATHEMATICIANS.

ON August 9, 10 and 11, the first International Congress of Mathematicians met in Zurich. By the morning of the 9th there were in attendance 200 members from all parts, viz.: from Switzerland, 53; Germany, 40; France, 25; Italy, 19; Russia, 18; Austria Hungary, 16; United States, 7; Sweden, 6; Denmark, 4; Belgium, England, Holland, 3 each; Greece, Portugal, Spain, 1 each. The gathering, while fairly representative of the different branches of pure mathematics, did not adequately represent applied mathematics. The meeting of the British Association in Toronto was doubtless responsible for the absence of many English mathematicians, who might otherwise have been at Zurich; but, even making allowance for this, the presence of *three* representatives of English mathematics can hardly be regarded as a sufficient recognition of the importance of the congress.

The regulations, while prescribing French and German as the official languages, make provision also for the use of English and Italian; and it is expressly laid down that in the appointment of the committee these languages shall be represented. This body, elected at the first general meeting, was therefore composed as follows:—President, Prof. Geiser; Secretaries, MM. Franel and Rudio; Hon. Secretaries, MM. Borel, Pierpoint, Volterra, E. v. Weber; Members, MM. Brioschi, Hobson, Klein, Mertens, Mittag-Leffler, Picard, Poincaré (absent), H. Weber. The principal office of the committee was to formulate the objects and methods of the series of congresses, and to give a preliminary consideration to certain matters with respect to which action must be taken by the next congress, to be held in Paris in 1900. Among these matters those of most pressing importance are the adoption of some scheme of classification of the various branches of mathematics, and the undertaking of some bibliographical work. As to the organisation of the series of congresses, it is decided that these shall meet in different countries at intervals of from three to five years. The advisability of giving continuity to the series by the

establishment of some permanent central body is affirmed, but action is deferred; this question will doubtless be ripe for discussion in 1900. The most tangible object of the congress is the encouragement of the production of detailed reports on different branches of mathematics, for which so admirable a model is afforded by the Brill-Noether "Bericht über Funktionen-theorie," published three years ago. Doubtless, too, the preparation of such reports will be materially assisted, and their international character secured, by the furthering of personal relations among mathematicians of different countries, which is laid down as one object of the congress. The arrangements so admirably planned and carried out by the Zürich committee of organisation gave all possible facilities for social intercourse, beginning with an informal gathering on the evening preceding the actual meetings, and including afternoon excursions on the lake and to the top of the Uetliberg.

Tuesday was given up to the reading of papers, for which five Sections were organised, each with President, Vice-President, and Secretary. (1) "Arithmetic and Algebra," Mertens, Peano, Amberg; (2) "Analysis and Theory of Functions," Picard, Brioschi, Jaccottet; (3) "Geometry," Reye, Segre, Künzler; (4) "Mechanics and Mathematical Physics," Jung, Joukowsky, Flatt; (5) "History and Bibliography," Moritz Cantor, Laisant, Schoute. The sittings of these Sections were arranged to begin at different hours of the morning and afternoon, to meet the natural desire of members to hear as many as possible of the leaders in different subjects. Papers of special interest were those of Brioschi, "Sur une classe d'équations du cinquième degré"; Picard, "Sur les fonctions de plusieurs variables"; Reye, "Neue Eigenschaften des Strahlenkomplexes zweiten Grades"; H. Weber, "Ueber die Genera in algebraischen Zahlkörpern"; Zeuthen, "Isaac Barrow et la méthode inverse des tangentes." Moreover, addresses were delivered at the opening and closing general meetings on Monday and Wednesday mornings by Poincaré, "Sur les rapports de l'analyse pure et de la physique mathématique"; Hurwitz, "Entwicklung der allgemeinen Theorie der analytischen Funktionen in neuerer Zeit"; Peano, "Logica Matematica"; Klein, "Zur Frage des höheren mathematischen Unterrichtes." In the much-regretted absence of M. Poincaré, his address was read by M. Franel.

Among the mathematicians present, in addition to those already named, were MM. Brill, Noether, G. Cantor, Dyck, Gordan, Korteweg, Larmor, F. Meyer, Osgood, Vassilief, Veronese, Enriques, Eneström.

THE BRITISH ASSOCIATION.

THE Toronto meeting of the British Association opened on Wednesday in last week, and came to an end yesterday, as we went to press. The reports which have reached us show that the meeting has been a successful one throughout, both from a social and also from a scientific point of view. As in 1884, when the Association met in Montreal, Canadians have shown by the enthusiastic reception given to the members that they value agencies which exist for the diffusion of knowledge and culture. The many papers read before the Sections by no means represent the whole result of such a gathering. The Dominion has been bound closer to the mother country, the interests of science have been brought before the notice of the public, and scientific knowledge will be advanced by the opportunity which the meeting has given for the exchange of ideas. The Montreal meeting of the Association was not only of value in assisting scientific education and research in Canada, but our Transatlantic contemporary—*Science*—acknowledges that it gave a considerable impulse to science